NuMI Technical Components

Commissioning Plan

February 18, 2004

Commissioning of the Technical Components is divided into 3 phases: a) system checkout, b) commissioning with primary beam to satisfy CD-4 requirements, and c) commissioning with primary beam to satisfy physics requirements. The NuMI Commissioning Coordinator is the L2 Manager for the Technical Components.

System checkout and beam commissioning is performed after all necessary safety approvals are granted. Safety professionals review all new systems when they are designed. The NuMI Project ES&H/QA Committee reviews systems that pose unique hazards prior to checkout and requests approval for initial turn-on by the Accelerator Division (AD) Division Head. These system specific safety approval requirements are noted in this document, but the safety approval process is not described.

System checkout and commissioning requirements are based on the NuMI pseudo-WBS structure. These are listed in Appendix A. Note that not all pseudo-WBS sub-systems require separate checkout or commissioning. For example, the horn power supply, stripline and horns must be checked out as a single system. For radiation shielding systems, there is no checkout activity, however there is a commissioning activity.

System Checkout

Level 3 managers are responsible for providing an operating system; hence system checkout is the responsibility of the L3 manager. The following section lists the major systems by pseudo-WBS along with a description of the checkout process for each. The WBS level 3 identifier precedes the system name. Prerequisites indicate which activities must precede checkout or commissioning. Safety approvals indicate the necessary safety approvals required before checkout can begin. Documentation describes the method for documenting that the checkout is complete.

1.BPM

Checkout by: Instrumentation Group
Prerequisites: Controls
Safety approvals: None

NuMI BPM's are equivalent to existing systems in the Main Injector transfer lines and are checked out by the AD Instrumentation group. BPM's are then readout via the control system without beam to monitor readback stability.

Documentation: NuMI Logbook

1.CONTROLS

Checkout by: Controls Group
Prerequisites: None
Safety approvals: None

The control system is equivalent to the existing system in the Accelerator Division in terms of components, instrumentation, and interface hardware and software facilities. The basic infrastructure of the Controls will be established early with respect to other systems. The basic infrastructure is realized by installation and termination of fiber optic cable, and connection of standard commercial and Fermilab specific hardware interfaces. Various professionals in the Controls Department of the Accelerator Division will accomplish this work. Much of the "commissioning" of Controls is actually associated with detailed testing of beamline instrumentation, utilities, and various unique device/system installations.

Documentation: NuMI Logbook

1.KICKER MAGNET – Hi Pot

Checkout by: EE Support
Prerequisites: 1.CONTROLS
Safety approvals: Electrical safety

The kicker magnet is hi-pot tested to a minimum of 2 kV prior to connecting the power cables.

Documentation: NuMI Logbook

1.KICKER COOLING

Checkout by: Mechanical Support
Prerequisites: 1.CONTROLS, 1.PERMIT
Safety approvals: Electrical safety

The kicker cooling system consists of a Fluourinert recirculation pump and chiller. Line pressures are checked and permit set points determined. The kicker magnet power supply permit is tested.

Documentation: NuMI Logbook

1.LOSS MONITOR

Checkout by: Instrumentation Group
Prerequisites: 1.CONTROLS, 1.PERMIT
Safety approvals: None

Most NuMI loss monitors are duplicates of existing systems in the accelerator complex. The carrier tunnel loss monitors have embedded radioactive sources to ensure their function.

Cables are checked for continuity. Charge is injected into each loss monitor signal cable and a check made of the control system readback. Loss monitor inputs to the beam permit system are tested.

After checkout, loss monitors are readout via the control system without beam to monitor stability. Extraction region loss monitor response is studied while the accelerator is running.

Documentation: NuMI Logbook

1.MAGNET

Checkout of conventional magnets is a joint activity with WBS 1.1.3

1.MAGNET – Water systems checkout

Checkout by: Water Systems Group
Prerequisites: LCW
Safety approvals: None

Water-cooling system checkout is done after the magnet is roughly aligned. Hoses are attached to the magnets, valves opened and a leak check performed

Documentation: NuMI Logbook

1. MAGNET PS – Polarity Checking

Checkout by: NuMI Beamline Physicist, Operations
Prerequisites: 7.LCW, 3.Magnet PS
Safety approvals: power-on access approval

Polarity checking is performed under specifically authorized low-power operation. Each magnet is individually run DC at low current and polarity checked by the Beamline Physicist. The results are correlated with the controls read-back values.

Documentation: NuMI Logbook

1.MULTIWIRE – Controls

Checkout by: Instrumentation, Operations
Prerequisites: 1.CONTROLS
Safety approvals: None

The profile monitor motor drive is run to the in/out limit switches and checked for proper shut-off. The foil position is read via the controls system and correlated with the physical position of the chamber. Pulsing individual channels in each plane and noting the proper display on the TV system check the wire plane readout. Database scale factors are checked.

Documentation: NuMI Logbook

1.MULTIWIRE – Alignment

Checkout by: AMG, Instrumentation
Prerequisites: 1.MULTIWIRE – Controls
Safety approvals: None

The alignment group measures the position of the fiducial marks relative to the beam centerline, and centers the monitor on the beam. The Instrumentation group uses the position read-backs and the measured positions to derive the database scale factors.

Documentation: NuMI Logbook

1.PERMIT

All inputs to the Beam Permit System (BPS) are individually checked to ensure proper behavior. Ideally, the inputs to the BPS are checked at the conclusion of the sub-system checkout. BPS inputs are described in NuMI Controls Requirements.

Checkout by: L3 managers, Operations
Prerequisites: None
Safety approvals: None

Documentation: NuMI Logbook

1.TOROID

Checkout by: Instrumentation
Prerequisites: 1.CONTROLS, 1.PERMIT
Safety approvals: None

Checkout of the beam toroid consists of testing for continuity. The toroids are readout via the control system without beam to monitor stability. The inputs to the beam permit system are checked.

Documentation: NuMI Logbook

2.CHASE COOL

Checkout by: NuMI Engineer
Prerequisites: 1.CONTROLS, 1.PERMIT
Safety approvals: None

The system cools and re-circulates air in the target pile.

Instrumentation is checked for proper read-back. Airflow balance through filters in filter bank is checked. Airflow balance is adjusted between bottom, sides, and top of chase. Any excessive air leaks are plugged. Temperature is set and checked. Check that loss of differential pressure or temperature-out-of-range drops the beam permit. The sound level is checked to see if hearing protection measures required.

Documentation: NuMI Logbook

2.HORN1 MODULE

Checkout by: NuMI Engineers and NuMI beamline Physicist, AMG
Prerequisites: 1.CONTROLS, 1.PERMIT, 7.RAW – Horn1
Safety approvals: See 3.HORN PS

The horn is a pulsed high current magnetic beam focusing device. It is water-cooled. It is mounted on a module that has positioning motors. An ionization chamber allows a crosscheck of beam alignment.

The horn positioning motor drives are run through their travel, with function of limit switches and position readbacks checked. Thermocouple readback is checked. The system is checked for leaks with the water system turned on. The horn is pulsed, with scope-check of expected pulse shape and a check that the bdot magnetic field monitoring is reading back properly. Ionization chamber readback is checked, and timing gate set. Final alignment is checked. Check that temperature-out-of-range on the horn drops the beam permit.

Documentation: checklist, survey results to L3 manager

2.HORN2 MODULE

Checkout by: NuMI Engineers and NuMI beamline Physicist, AMG
Prerequisites: 1.CONTROLS, 1.PERMIT, 7.RAW – Horn2
Safety approvals: See 3.HORN PS

The module is the same as horn 1 module, except module 2 does not have motor positioning.

Thermocouple readback is checked. System is checked for leaks with water system turned on. Horn is pulsed, with scope-check of expected pulse shape and check of the bdot monitor. Ionization chamber readback is checked, and timing gate set. Final alignment is checked by survey. Check that temperature-out-of-range on the horn drops the beam permit.

Documentation: checklist, survey results to L3 manager

2.TARGET

Checkout by: NuMI Engineers and NuMI beamline Physicist, AMG
Prerequisites: 1.CONTROLS, 1.PERMIT, 7.RAW - Target, 2.Horn1 Module
Safety approvals: None

The baffle is an aluminum-encased graphite tube with a hole in the center for beam. The baffle intercepts mis-steered beam, so it cannot hit the horn or target cooling system. The baffle system includes thermocouples. The baffle and target are mounted on the target/baffle module, which includes a motor driven positioning system and thermocouples.

Thermocouple readout is checked. The positioning motor drives are run through their travel, with function of limit switches and position readbacks checked. The target outer case is checked to have high electrical impedance to ground. The motorized drive of the target forward into the low energy position is done carefully to check that there is no interference between the target and horn 1, watching that the target outer case does not short to the horn. System is checked for fluid leaks with water system turned on. System is checked for air leaks with vacuum system turned on, and vacuum gauge readout is checked. The target helium pressure gauge readback is checked. The charge ejection monitoring system is checked for shorts, and the timing gate for it set. Final alignment is checked by survey. Check that temperature-out-of-range on baffle drops the beam permit.

Documentation: checklist, survey results to L3 manager

2.WORKCELL

Checkout by: NuMI Engineer and NuMI beamline Physicist
Prerequisites: None
Safety approvals: ES&H procedure for remote operation of shielding door; draft of radioactivated component change-out procedure

The workcell provides the capability to change-out broken components from the modules while people are protected behind radiation shielding. It includes a remotely controlled shielding door and lifting tables. The shielding door will be run through its travel, and function of limit switches checked. The five degrees of motion of the lifting tables (three electrical and two hydraulic) will be run through. The pressure gauge readback will be checked. The fit of top shielding covers over modules in the workcell will be checked. A complete run-through of a horn change-out will be done, checking the adequacy of the horn change-out procedure.

Documentation: checklist, finalized change-out procedure to L3 manager

3.HORN PS & TRANSMISSION LINE

Checkout of the horn power supply and transmission line is joint activity.

3.HORN PS - Controls

Checkout by: EE Support
Prerequisites: 1.CONTROLS
Safety approvals: None

Check controls for the PEI charging supplies and power supply readback through the control system. This will be done initially at MI8 and tested again after installation in the Power Supply room.

Documentation: NuMI Logbook

3.HORN PS - Water

Checkout by: Mechanical Support, EE Support
Prerequisites: 7.LCW-US
Safety approvals: None

Pressure test PEI water supply and check for leaks.

Documentation: NuMI Logbook

3.HORN PS - Interlocks

Checkout by: EE Support, Interlock group
Prerequisites: 1.PERMIT, Interlock group documentation
Safety approvals: None

Device and personnel protection interlocks are installed by the AD Interlock group. The interlocks are tested to ensure that the PS is enabled with the proper water and air-cooling systems inputs and access door interlocks.

Documentation: NuMI Logbook

3.HORN PS - Hi-pot

Checkout by: EE Support
Prerequisites: None
Safety approvals: Power-on access approval.

Guards and barriers are installed in the target hall around the stripline. A thorough visual inspection of the stripline and horn is done. The stripline and horn are hi-pot tested to a minimum of 2 kV prior to connecting the stripline to the capacitor bank.

Documentation: NuMI Logbook

3.HORN PS - Pulse horn

Checkout by: EE Support
Prerequisites: 3.HORN PS – Controls, Water, Interlocks, Hi-pot, 2.CHASE COOL
Safety approvals: Power-on access approval.

The link between the capacitor bank and the stripline is installed. The PS is run to it's full current.

Documentation: NuMI Logbook

3.HORN PS - Power test

Checkout by: EE Support
Prerequisites: 3.HORN PS - Pulse horn
Safety approvals: Power-on access approval

The PS is run to it's full current for 24 hours to check for electrical or mechanical problems.

Documentation: NuMI Logbook

3.KICKER PS - Controls

Checkout by: EE Support
Prerequisites: 1.CONTROLS
Safety approvals: None

Kicker power supply instrumentation is checked for consistency between local values and controls readback.

Documentation: NuMI Logbook

3.KICKER PS - Interlocks

Checkout by: Interlock Group
Prerequisites: 1.PERMIT, Interlock group documentation
Safety approvals: None

Device and personnel protection interlocks are installed by the AD Interlock group. The interlocks are tested to ensure that the PS is enabled with the proper water-cooling systems inputs and access door interlocks.

Documentation: NuMI Logbook

3. KICKER PS - Hi-pot

Checkout by: EE Support
Prerequisites: None
Safety approvals: None

Cables are connected to the kicker magnets. A hi-pot test to 2 kV is done.

Documentation: NuMI Logbook

3. KICKER PS – Pulse kicker

Checkout by: EE Support
Prerequisites: 3. KICKER PS – Controls, Interlocks, Hi-pot
Safety approvals: None

The kicker is pulsed and measurements made of voltage, current and stability. The kicker timing is adjusted relative to the beam synch clock. The kicker magnet current input to the beam permit is tested.

Documentation: NuMI Logbook

3. MAGNET PS

Checkout of conventional magnet power supplies is a joint activity with WBS 1.1.1.

3. MAGNET PS - Controls

Checkout by: EE Support
Prerequisites: 1.CONTROLS, 1.PERMIT
Safety approvals: None

Power supply controls and voltage regulation is checked. Magnet design current settings are entered in the permit system with appropriate windows. The magnet power supply and permit system are tested to ensure that current trip levels are acceptable.

Documentation: NuMI Logbook

3. MAGNET PS – Power Test

Checkout by: Operations
Prerequisites: 7.LCW, 3. MAGNET PS - Controls
Safety approvals: Power supply operation

Sections of the beamline are run in the appropriate ramped or DC mode at full power for at least 12 hours for final acceptance testing. This test is done with the Main Injector operating.

Documentation: NuMI Logbook

3. MAGNET PS – Critical Device

Checkout by: Interlock group
Prerequisites: 3.MAGNET PS - Controls
Safety approvals: Special RSO lockout for testing

The Lambertson magnets and HV102 are the NuMI beamline critical devices. Verification is made of the power supply operation when the critical device permit is dropped.

Documentation: NuMI Logbook. Test documentation provided to RSO?

4.ABSORBER - Water

Checkout by: MSD
Prerequisites: 7.RAW - Absorber
Safety approvals: None

The absorber core cooling system is pressure tested. The absorber RAW system is operated after final connections to the core are made. The system is inspected for water leaks.

Documentation: NuMI Logbook

4.ABSORBER - Controls

Checkout by: EE Support
Prerequisites: 1.CONTROLS, 7.RAW – Absorber, 1.PERMIT
Safety approvals: None

Thermocouples are checked out and connected to the control system and the permit system. Thermocouple inputs to the beam permit system are tested.

Documentation: NuMI Logbook

5.HADRON MONITOR

Checkout by: MINOS Collaborators, RSO
Prerequisites: Controls
Safety approvals: None

The NuMI team and AD Radiation Safety will practice removal, disposal, and replacement of the monitor to simulate what may happen in the event of the future failure of a detector. Time and motion studies will be performed.

The NuMI team will check out the readout electronics, HV controls, and gas system. A final checkout will be done using a small radioactive source.

Documentation: NuMI Logbook, MINOS Logbook

5.MUON MONITOR

Checkout by: MINOS Collaborators
Prerequisites: Controls
Safety approvals: None

The NuMI team will check out the readout electronics, HV controls, and gas system. Final calibration runs will be taken using internal sources mounted inside the detectors.

Documentation: NuMI Logbook, MINOS Logbook

7.LCW – US, DS

Checkout by: AD Water group
Prerequisites:
Safety approvals: See FESHM 5034

Checkout of all LCW and RAW systems follow the same procedure.

Once installed and connected to AC power, pump motors are bumped to check for proper rotation. A journeyman electrician and a technician from the AD WATER GROUP perform this check.

After all piping is completed and all equipment is installed, the system is filled with water, manually pressurized via a hand pressure-testing pump and inspected for leaks. It is customary to hold the system at the design pressure for a minimum of 15 minutes. Any drop in the pressure indicates a leak. Once the system has been demonstrated to be

leak tight, the leak tests are documented in the engineering note. Technicians in the AD WATER GROUP usually perform leak testing. FESHM 5034 dictates safety requirements to be met during pressure testing.

Documentation: Engineering Note, NuMI Logbook

7.RAW – TARGET, HORN 1, HORN 2, ABSORBER, DECAY PIPE

See 7.LCW.

7.UTIL INST

Checkout by: AD Controls group
Prerequisites: None
Safety approvals: None

Instrumentation (temperature elements, pressure elements, conductivity elements, etc) that provide an electronic output signal are calibrated. The PLC is programmed with the scaling factors to indicate the process variables in engineering units. The PLC is programmed and communication established with the controls system (ACNET).

Documentation: NuMI Logbook

7.VACUUM – PRIMARY BEAM

Checkout by: AD Vacuum group
Prerequisites: 3. MAGNET PS – Power Test, 1.MULTIWIRE – Alignment
Safety approvals: None

Roughing and turbo pumps are brought in to pull a hard vacuum on the system. Leak checking may be done depending on how well the pump-down matches the predicted rate and the ultimate vacuum achieved with the turbo pumps. After the desired vacuum is reached, the ion pumps are started and the roughing pumps removed.

Documentation: NuMI Logbook

7.VACUUM – DECAY PIPE

Checkout by: AD Vacuum group, design engineer
Prerequisites: None
Safety approvals: See FESHM 5033

Once installed and connected to AC power, pump motors are bumped to check for proper rotation. A journeyman electrician and a technician from the Mechanical Support department perform this step.

Once the decay pipe vacuum system piping is complete, instrumentation calibrated and appropriate safety approvals granted, the pump is started and pump-down of the 75,000 cubic foot decay pipe begun. Pressure is plotted and compared to predicted values. Differences between predicted and actual values need to be understood. The design engineer generally does this.

Documentation: NuMI Logbook

8.ENVIRONMENTAL MONITORING

Checkout by: ES&H Section
Prerequisites: None
Safety approvals: None

The Environmental and Radiation Monitoring systems are similar to existing systems throughout the Laboratory in terms of components and instrumentation. Checkout, commissioning and operation of these systems is done using standard procedures by the Environmental and Radiation Protection Groups in the ES&H Section. Various groups within the ES&H Department of the Accelerator Division may be involved with selected commissioning efforts.

The ES&H Section is responsible for periodic monitoring of all sampling wells on the Fermilab site. Baseline samples are taken before NuMI operation begins and regularly during operations.

Documentation: ES&H Section documents

8.FIRUS

Checkout by: Controls Group
Prerequisites: None
Safety approvals: None

The Fire and Utility Monitoring System (FIRUS) is similar to existing systems throughout the Laboratory. FIRUS capability will be established at MI-65 and MINOS sites as the Laboratory receives beneficial occupancy from the Service Building and Outfitting Subcontractor. The new capability is easily accomplished by extension of FIRUS from the MI-62 Service and MiniBooNE Detector Buildings. Technical professionals within the Controls Department of the Accelerator Division perform checkout and commissioning of the new FIRUS system connections.

Documentation: NuMI Logbook

8.CATV

Checkout by: PPD Cable TV group
Prerequisites: None
Safety approvals: None

The NuMI CATV System is similar to existing CATV systems throughout the Laboratory. CATV capability will be established at MI-65 and MINOS sites soon after the Laboratory receives beneficial occupancy from the Service Building and Outfitting Subcontractor. The new capability is easily accomplished by extension of existing CATV from the MI-62 Service and MiniBooNE Detector Buildings. Technical professionals within the Cable TV

Group of the Particle Physics Division perform checkout and commissioning of the new CATV system connections.

8.RAD SAFETY

Checkout by: AD Interlock group
Prerequisites: None
Safety approvals: None

The NuMI Radiation Safety System is fundamentally similar to existing systems in the Accelerator Division in terms of components, instrumentation and techniques of control. Checkout and commissioning of the system is done using standard procedures developed by the Interlock Group of the ES&H Department of the Accelerator Division. Testing of the NuMI RSS is procedurally limited to certain qualified individuals.

Documentation: NuMI Logbook

Commissioning for CD-4

When all system checkouts are completed, the NuMI Technical Components are physically ready for commissioning with beam. The AD Head grants approval for start of commissioning when all necessary safety reviews have been completed, the Safety Envelope is approved, and the Run Condition's are approved. The beamline Run Condition documents the radiation safety interlock status and any administrative controls that must be in place before Operations is authorized to transport beam. The Run Condition states the maximum beam intensity that is authorized.

The NuMI Project CD-4 goals are described in the Project Management Plan and are reproduced in the following table. Note that only those commissioning goals that are pertinent to the Technical Components are described in the following sections.

Goal	Parameter	Measurement	Commissioning Goal	WBS
1	Proton intensity in target hall	Toroid (or equivalent) beam intensity at entrance to the Target Hall	Greater than 1E12 120 GeV protons/spill	1.1
2	Beam alignment	Transverse distributions of the proton beam and secondary beams	Proton direction established to within 1 mr of the known direction to the Far Detector in the Soudan mine.	1.1
3	Neutrino beam energy	Near detector event energy	Low energy, 2-4 GeV	1.1, 2.0
4	Cosmic ray muons detected in the MINOS near detector	Near detector data read out through DAQ system	Majority of 153 near detector planes sensitive to muons	2.0
5	Near detector neutrino flux	Charged current event rate in 1.5 ton fiducial region	Observer neutrinos in the near detector produced by the NuMI beam	1.1, 2.0
6	Cosmic ray muons and atmospheric neutrinos detected in each of the two MINOS far detector super-modules	Far detector data read out through DAQ system	Majority of the 484 planes of the far detector sensitive to muons and atmospheric neutrinos	2.0

To accomplish goals 1 and 2 (WBS 1.1 Goals), the proton beam must be transported with low loss and traverse the entire extent of the beam transport line, the target hall and decay pipe. The two toroid monitors and several BPM's measure the beam intensity. The measurement that confirms the beam direction is the beam position in the hadron

monitor located in front of the hadron absorber. These two goals are met with the target in the out position.

To accomplish goals 3 and 5 (WBS 1.1 & 2.0 Goals), the target is inserted into the beam for a period of time sufficient measure the neutrino event rate and energy distribution in the near detector.

In the following sections, the term “Commissioned by” denotes the L3 manager who has the highest priority for control of the beam. “Prerequisites” is the required state of the beamline to begin the commissioning step.

WBS 1.1 Goals

Beam commissioning proceeds in several phases with increasing intensity. The beamline state is defined as follows:

1) The Beam Permit System is programmed to inhibit beam if a) the intensity exceeds 4E11 protons/pulse (ppp), b) beam exists in the first batch, c) there are significant losses in the P1 line or in the Main Injector.
2) Beam Permit System magnet current trip levels are set to allow tuning flexibility.
3) The initial beam intensity in the Main Injector is adjusted to ~3E11 ppp with a cycle time of ~1 minute. This is done with a single batch and a single turn.
4) NuMI dipole and quadrupole magnets are ramped at the design values.
5) Multi-wire monitors are inserted in the beamline.
6) The NuMI target and baffle are moved out of the beam.

Prior to initial beam extraction to NuMI

Commissioned by: WBS 1.1.1
Prerequisites: NuMI beam disabled
Safety approvals: NuMI critical device test

Multi-batch beam is established in the Main Injector with NuMI disabled. The first batch is extracted to pbar if it is operating. The second (NuMI) batch is diverted to the Main Injector abort. A measurement of the emittance and momentum spread is used to determine the optimum NuMI quadrupole currents. The extraction time is determined from the bunch phase rotation to achieve the minimum momentum spread. Magnet and BPM timing is adjusted relative to the extraction time. The AUTOTUNE program is run parasitically to ensure that NuMI magnet currents and monitoring devices are properly read.

Initial beam extraction & tuning

Commissioned by: WBS 1.1.1
Prerequisites: Stable Main Injector beam
Safety approvals: Run Condition for 2E12

All NuMI beamline magnets and instrumentation are data logged during initial extraction. Beam is extracted into the NuMI line. The profile monitors monitor the beam position. BPM’s are calibrated relative to the multiwire positions. The AUTOTUNE program is run

in manual mode to facilitate beam tuning. Beam losses are measured. If necessary, studies are conducted to identify loss points and corrections made to the magnet currents.

Intensity increase to 1E12 ppp

Commissioned by: WBS 1.1.1, 1.1.5
Prerequisites: Stable Main Injector beam
Safety approvals: Run Condition approved for 2E12 ppp

The beam intensity is raised to 1E12 ppp; sufficient to observe a profile on the hadron monitor that is centered on the line to Soudan, MN. The intensity is measured by the toroid in the pre-target area and the target BPM's. The hadron monitor timing is checked. Record beam profile, and correlate amplitude to primary beam intensity as given by the beam toroid. Scan beam horizontally and vertically to baseline sensitivity of the monitor to beam offsets.

The beam direction to the far detector is determined by the beam position in the pre-target region as measured by the profile monitors, the beam position at the hadron monitor and the distance between these points.

Loss Monitors are calibrated by inserting and retracting the profile monitors and by inserting the calibration target. Allowable loss monitor trip limits are determined. Loss limits are programmed into the Beam Permit System. The Beam Loss Budget Monitor is started.

The achievement of commissioning goals 1 and 2 is documented.

WBS 1.1 & 2.0 Goals

Completion of goals 3 and 5 require the simultaneous operation of the beamline with the target inserted and the MINOS near detector.

Radiation survey

Commissioned by: WBS 1.1.2
Prerequisites: Stable low intensity beam, target in, Near Detector operational
Safety approvals: None

The target is moved into the beam for the first time. Beam-on radiation surveys are conducted to measure dose rates at the base of the target shaft and in the absorber access tunnel. This information will be used to confirm the required location of fences and gates at higher intensity.

The MINOS near detector is operated

Horn alignment

Commissioned by: WBS 1.1.2
Prerequisites: Stable low intensity beam, target out
Safety approvals: None

The beam intensity is set to ~3E11 ppp and the target is moved out of the beam. The gate timing of the target chase ionization chamber is checked. With target/baffle still lowered out of beam scan beam horizontally and vertically +/- 11 mm. Interactions on horn cross hairs and horn 1 inner conductor produce a signal in the cross hair ionization chambers that will check agreement of beam centerline with horn positions. If disagreement is found, recheck component positions and beam multiwire chamber positions with survey and downstream hadron monitor beam position.

Documentation: NuMI Logbook

Horn pulse timing

Commissioned by: WBS 1.1.2
Prerequisites: Stable low intensity beam, target out
Safety approvals: None

With horn pulsing, compare the beam arrival time (according to the Budal and ionization chamber) with the peak of the horn current pulse, and adjust the current pulse timing if necessary.

Documentation: NuMI Logbook

Target and baffle alignment – medium energy

Commissioned by: WBS 1.1.2
Prerequisites: Stable low intensity beam, target in medium energy position
Safety approvals: None

With target/baffle raised to nominal beamline position, and with the target located in medium energy position, scan beam horizontally and vertically +/- 7 mm. Interactions with baffle will produce signal in alignment ionization chambers that will check agreement of beam centerline with baffle position. Interactions with the target will produce signals in the charge ejection (Budal) target monitors and the alignment ionization chambers, which will check agreement of beam centerline with target position. If disagreement is found, recheck component positions with survey. The timing of the Budal gate is checked at the beginning of this step. Check profile in hadron monitor system. Use beam-on-baffle data to calibrate baffle thermocouple response to proton intensity.

Documentation: NuMI Logbook

Target and baffle alignment – low energy
Data taking with the near detector

Commissioned by: WBS 1.1 and 2.0
Prerequisites: Low intensity beam, target in low energy position
Safety approvals: None

The target is moved to the low energy position and with horns turned off, the beam scans are repeated to check the baffle and target alignment. Also check profile in muon monitoring system.

Neutrino events are logged in the near detector when horn pulsing begins. A comparison is made of the spectrum of events logged when the target is in the medium energy and the low energy position. If there are an insufficient number of low energy events to demonstrate that the commissioning goals are met, the beam intensity or running time is increased.

Documentation: NuMI Logbook, MINOS Logbook, Memo to DOE

The achievement of commissioning goals 3 and 5 is documented.

Commissioning for Physics

A variety of beam tuning, calibration and alignment steps must be completed at high intensity before the Operations Group routinely operates the beamline. This is an important dividing line, since once high intensity beam has been run the target pile will be significantly radioactivated, complicating any further investigations of problems encountered.

The following activities are necessary before routine operation begins. Some of these activities may be done concurrently, in contrast to earlier phases of commissioning.

Beam Tuning

Commissioned by: WBS 1.1.1
Prerequisites: None
Safety approvals: Approved Run Conditions for 3E13 ppp

The beam intensity is raised in intensity by ~5E12 ppp. Measurements are made of beam emittance and quality. Losses are studied and corrections made as necessary. This process is repeated until a stable operating condition is reached.

Beam permit inputs are set to “normal operation” windows that are determined by loss studies and operating experience.

Documentation: NuMI Logbook

Baffle energy deposition and alignment – medium energy

Commissioned by: WBS 1.1.2
Prerequisites: None
Safety approvals: None

The edges of the baffle are scanned with high intensity beam. Interactions in the baffle will produce a signal in the baffle thermocouples, allowing a cross check of alignment.

Beam is steered onto the target hall baffle, checking that the beam permit is inhibited after about 20 high intensity pulses by the baffle thermocouple system.

Documentation: NuMI Logbook

Muon monitor commissioning

Commissioned by: WBS 1.1.5
Prerequisites: None
Safety approvals: None

Pulse the horns with beam centered on target in the medium energy position. Check timing gate for monitor chambers. Record monitor beam profiles, and correlate amplitude to primary beam intensity as given by beam toroid amplitude. Scan beam horizontally and vertically to baseline sensitivity of monitors to beam offsets. The horn pulse amplitude and timing is scanned to baseline the sensitivity of the monitors to horn power supply offsets.

Documentation: NuMI Logbook, MINOS Logbook

Near detector energy spectra and rates

Commissioned by: WBS 2.0
Prerequisites: None
Safety approvals: None

Reference spectra are taken in the near detector for both the medium and low energy beams.

Documentation: MINOS Logbook

Radiation surveys

Commissioned by: AD Radiation Safety
Prerequisites: None
Safety approvals: None

The air activation at the exhaust vents is measured. Corrective measures may be required, i.e. sealing air leaks in the target hall chase, sealing air leaks in the hadron absorber, reducing air flow rates.

Beam-on radiation and residual radiation surveys are conducted. Beam tuning may be required if residual dose rates are too high.

Documentation: NuMI Logbook

The beamline configuration and beam status is completely documented to serve as a baseline for the future.

Appendix A

Pseudo-WBS System Checkout & Commissioning Requirements

System	Checkout Req'd?	Checkout Comments	Commissioning Req'd?	Commissioning Comments
Extraction & Primary Beam				
1.BEAM	NA	Beam design	NA	
1.BPM	Yes		Yes	
1.CONTROLS	Yes		No	
1.INSTRUMENT	NA	Design activity	NA	
1.KICKER	Yes		Yes	
1.KICKER COOLING	Yes		No	
1.LAMBERTSON	Yes	Same as conventional magnets	Yes	
1.LOSSMON	Yes		Yes	
1.MAGNET	Yes		Yes	
1.MI/P150	NA	MI/P150 studies	NA	
1.MULTIWIRE	Yes		Yes	
1.PERMIT	Yes		Yes	
1.STAND	No	Magnet stands	No	
1.TOROID	Yes		Yes	
Neutrino Beam Devices				
2.BAFFLE	Yes	Checkout w target	Yes	Commission w target
2.CHASE COOL	Yes		Yes	Check air activation
2.HELIUM	NA	Dropped from scope	NA	
2.HORN PROTO	NA	Prototype activity	NA	
2.HORN1	Yes	Checkout w module	Yes	Commission w module
2.HORN1 MODULE	Yes		Yes	
2.HORN2	Yes	Checkout w module	Yes	Commission w module
2.HORN2 MODULE	Yes		Yes	
2.HORNS	NA	Generic horn design	NA	
2.MODULES	NA	Generic module design	NA	
2.PROTO TARG	NA	Prototype activity	NA	
2.SHIELD	No	No active components	No	

2.SHIELD CARRIAGE	No	No active components	No	
2.SHIELD CHASE	No	No active components	No	
2.SHIELD TBLOCK	No	No active components	No	
2.SHIELD TOP	No	Checkout w chase cooling system	Yes	
2.TARGET	Yes	Checkout w module	Yes	Commission w module
2.TGT MODULE	Yes		Yes	
2.WORKCELL	Yes		No	NA
Power Supply Systems				
3.FLEXJOINT	Yes		Yes	Commission w module
3.FLEXJOINT PROTO	NA	Prototype activity	NA	
3.HORN PS	Yes		Yes	Commission with horn
3.HORN PS PROTO	NA	Prototype activity	NA	
3.KICKER PS	Yes		Yes	Commission with kicker
3.POWER SUPPLY	Yes		Yes	Commission with magnets
3.SCR	No	Design activity	NA	
3.XLINE	Yes		Yes	Commission with horn
3.XLINE PROTO	No	Prototype activity	NA	
Hadron Decay & Absorber				
4.ABS CORE	Yes		Yes	
4.ABS SHIELD	No	No active components	Yes	Check air activation
4.ABSORBER	NA	Design activity	NA	
4.DECAY	Yes		Yes	Commission with decay pipe vacuum system
Neutrino Beam Monitoring				
5.HAD MON	NA	Design activity	NA	
4.HAD MON D/S	Yes		Yes	
5.MONITOR	NA	Design activity	NA	
5.MUON MON	Yes		Yes	
5.GAS	Yes		No	
Alignment Systems				
6.ALIGN	No	Support activity	No	
Water, Vacuum & Gas Systems				
7.GAS	??		No	
7.LCW	Yes		No	
7.RAW	Yes		No	
7.UTIL INST	Yes		No	

7.VACUUM - PRIMARY BEAM	Yes		No	
7.VACUUM - DECAY PIPE	Yes		No	
7.WATER	NA	Design activity	NA	
Controls, Interlocks & Cable Installation				
8.CABLES	No		No	
1.Controls	Yes		No	
8.ENV MON	Yes		No	
8.FIRUS/TV	Yes		No	
8.INTEGRATION	NA		No	
8.BEAM PERMIT	Yes		Yes	
8.RAD SAFETY	Yes		Yes	